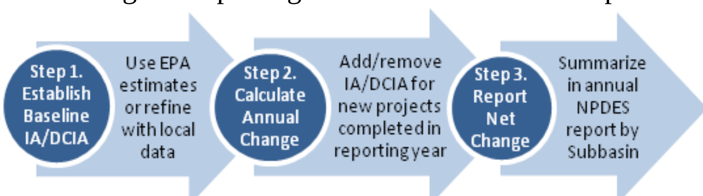
Estimating Change in Impervious Area (IA) and Directly Connected Impervious Areas (DCIA) for New Hampshire Small MS4 Permit

Small MS4 Permit Technical Support Document, April 2011

Draft NPDES Permit Focuses on DCIA

The 2010 NPDES Small MS4 permits for New Hampshire require regulated communities to estimate the number of acres of **impervious area** (**IA**) and **directly connected impervious area** (**DCIA**) that have been added or removed each year due to development, redevelopment, and or retrofitting activities (Draft Permit Section 2.3.6.8 (c)). Beginning with the second year annual report, IA and DCIA estimates must be provided for each subbasin within your regulated MS4 area. This technical support tool outlines accepted methods for estimating and reporting IA and DCIA in three steps:



What does DCIA really mean?

Impervious surfaces such as roadways, parking lots, rooftops, sidewalks, driveways, and other pavements impede stormwater infiltration and generate surface runoff. Research has shown that total watershed IA is correlated with a number of negative impacts on our water resources such as increased flood peaks and frequency, increased sediment, nutrient, and other pollutant levels, channel erosion, impairments to aquatic biota, and reduced recharge to groundwater (Center for Watershed Protection, 2003). Typically watersheds with 4-6% IA start to show these impacts, though recent work has found lower % IA threshold values for sensitive species (Wenger *et* al., 2008). Watersheds exceeding 12% IA often fail to meet aquatic life criteria and narrative standards (Stanfield and Kilgore, 2006).

For the purposes of the MS4 permit, DCIA is considered the portion of IA with a direct hydraulic connection to the permittee's MS4 or a waterbody via continuous paved surfaces, gutters, drain pipes, or other conventional conveyance and detention structures that do not reduce runoff volume. DCIA does not include:

- IA draining to stormwater practices designed to meet recharge and other volume reduction criteria.
- Isolated IA with an indirect hydraulic connection to the MS4, or that otherwise drain to a pervious area.
- Swimming pools or man-made impoundments, unless drained to an MS4.
- The surface area of natural waterbodies (e.g., wetlands, ponds, lakes, streams, rivers).

Accepted Methods for Estimating IA & DCIA

Step 1. Establish Baseline IA/DCIA

Use the estimates of existing IA and DCIA provided by EPA to establish the baseline acreage from which future additions or reductions of impervious cover can be tracked and measured.

For each regulated municipality in New Hampshire, EPA will provide graphical and tabular estimates of IA/DCIA ordered by land use type and subbasin. **Permittees may simply use these baseline estimates as is, or develop more accurate estimates when justified.** This may include using local data to refine EPA's estimates or the direct measure of IA (**Figure 1**). If the EPA estimates are not used for the baseline, permittees must provide in the annual report a description of the alternative methodology used.

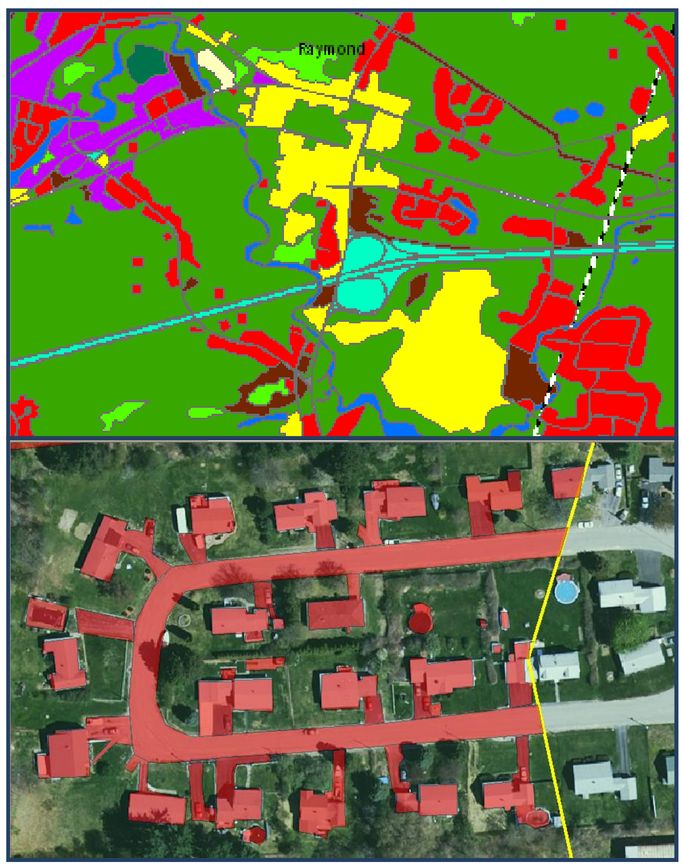


Figure 1. EPA will use statewide land use data (GRANIT), subbasin boundaries, and land use impervious coefficients to estimate baseline IA for each MS4 jurisdiction (upper). Communities may choose to refine these estimates with direct measure of IA where local GIS capacity is available, as shown here from Somersworth, NH (lower).

Why Quantify Your IA & DCIA?

New construction, redevelopment, and restoration activities can change existing IA and DCIA – potentially exacerbating or reducing existing watershed impairments. Understanding watershed imperviousness is important for communities because it:

- Informs management of impaired waterbodies and prioritization of watershed restoration efforts;
- Facilitates investigation of existing chronic flooding and stormwater drainage problems, and avoidance of new problems;
- Indicates potential threats to drinking water reservoirs/aquifers; commercial fisheries, and recreational waters;
- Demonstrates progress toward achieving future **Total Maximum Daily Load (TMDL)** allocations based on impervious cover thresholds;
- Serves as an educational tool for encouraging environmentally sensitive land use planning and **Low Impact Development (LID);**
- Facilitates equitable derivation of possible stormwater utility fees based on parcel-specific impervious cover; and
- Provides guidance for stormwater retrofit efforts.

Based on the established IA, DCIA can be estimated using empirical formulas developed by Sutherland as a function of watershed type (CWP, 2000). **Table 1** provides approved IA coefficients to be used for this approach. These coefficients were derived from previous studies and used by EPA to establish baseline conditions for regulated New Hampshire communities using **Equations 1** and **2**.

Eq. 1 IA_{Lui}= Total $acres_{Lui}$ * %IA

Eq. 2 Total Subbasin IA=$\sum_{i=1}^{n} IA_{Lui}$

Table 1. Estimating DCIA as a function of Land Use[1]

Land Use	% IA
Commercial	76
Industrial	56
High density residential	51
Med. density residential	38
Low density residential	19
Institutional	34[2]
Agricultural	2
Forest	1.9
Open Urban Land	11

[1] IA coefficients taken from Rouge River Study/EPA
[2] Institutional land use coefficient from Cappiella and Brown, 2001

Table 2 summarizes the appropriate Sutherland equations to apply for estimating DCIA from IA for *average*, *highly connected*, *totally connected*, *somewhat connected*, and *mostly disconnected* watersheds. **Permittees may opt to refine DCIA estimates to better reflect actual basin conditions where justified.**

Table 2. Sutherland Equations to Determine DCIA (%)

Watershed Selection Criteria	Assumed Land Use	Equation *(where IA(%) ≥1)*
Average: Mostly storm sewered with curb & gutter, no dry wells or infiltration, residential rooftops not directly connected	Commercial, Industrial, Institutional/ Urban public, Open land, and Med. density residential	$DCIA=0.1(IA)^{1.5}$
Highly connected: Same as above, but residential rooftops are connected	High density residential	$DCIA=0.4(IA)^{1.2}$
Totally connected: 100% storm sewered with all IA connected	--	DCIA=IA
Somewhat connected: 50% not storm sewered, but open section roads, grassy swales, residential rooftops not connected, some infiltration	Low density residential	$DCIA=0.04(IA)^{1.7}$
Mostly disconnected: Small percentage of urban area is storm sewered, or 70% or more infiltrate/disconnected	Agricultural; Forested	$DCIA=0.01(IA)^{2}$

Step 2. Calculate Annual Change

Once baseline IA/DCIA is established for each subbasin, permittees must annually track the change in IA and DCIA acreage from development, redevelopment, and retrofit projects completed that year.

To account for the estimated annual change in DCIA, permittees will need to determine how much IA and DCIA have been added or removed as a result of individual development, redevelopment, or retrofit projects completed during the reporting period.

The acres of DCIA for each project will be based on two factors: **(1) the amount of site IA, and (2) the effectiveness of stormwater best management practices (BMPs)** employed to reduce associated runoff. Practices that reduce runoff volume will lower DCIA. Note that practices that remove stormwater pollutants but do not provide runoff reduction benefits are not considered effective at reducing DCIA.

This information must be obtained from site plans and verified by as-built drawings or site inspection upon project completion. For all completed projects:

(1) Determine the former and new IA for each site.

(2) Determine the number and type of existing and/or new BMP(s) used, and calculate the amount of IA removed, managed, and unmanaged draining to each BMP.

(3) For each BMP designed in accordance with specifications provided in New Hampshire Stormwater Manual Stormwater Handbook (Vol. 2, Ch. 4), select the appropriate "disconnection" multiplier from **Table 3**. For infiltration trenches or basins, determine appropriate runoff volume reduction using **Tables 4** and **5** depending on site-specific soil infiltration rates and runoff depth captured as derived from the EPA 2010 BMP Performance Curves. Use **Equation 3** to generate the "disconnection" multiplier.

Eq. 3 Multiplier = 1 - % Runoff Reduction Volume/100

(4) Calculate DCIA for each BMP using **Equation 4** if adding newly created IA at new construction or redevelopment site, OR by using **Equation 5** if reducing existing IA in a retrofit or redevelopment scenario.

Eq. 4 Added $DCIA_{BMPi} = IA_{BMPi}$ * BMP Multiplier

Eq. 5 Reduced $DCIA_{BMPi} = IA_{BMPi}$ * (1 – BMP Multiplier)

(5) Calculate DCIA for entire project site draining to BMPs by summing DCIA for individual BMPs using **Equation 6**.

Eq. 6 Site $DCIA_{added} = \sum_{i=1}^{n} DCIA_{BMPi}$ + New Unmanaged IA

Table 3. Determining DCIA based on Interim Default BMP Disconnection Multiplier or EPA's Infiltration Curves

BMP Description	% Runoff Volume Reduction[1]	BMP "Disconnection" Multiplier[2]
Removal of pavement; restore infiltration capacity	100%	0
Redirection of rooftop runoff to infiltration areas, rain gardens or dry wells	85%	0.15
Permeable pavement, bioretention, dry/vegetated water quality swales	75%	0.25
Infiltration trenches	15-100%	0.85-0
Infiltration basins	13-100%	0.87-0
Non-runoff reduction practices (i.e., detention ponds, wetlands, sand filters, hydrodynamic separators, etc)	0%	1.0

[1] Interim default values for % runoff reduction are based on Schueler 2009 and are subject to change as more data becomes available. Values for infiltration trenches and basins are based on soil infiltration rates and depth of runoff treated. See Tables 3 and 4 to determine the site specific values to apply.
[2] BMP multiplier = 1 - %Runoff Volume Reduction/100

Step 3. Report Net Change in IA & DCIA

Starting in year 2, permittees must include a summary of net changes in IA/DCIA by subbasin and document methodology in its annual report.

Permittees will be required to summarize IA and DCIA estimates for all completed construction, redevelopment, and retrofit projects within each subbasin. **EPA will provide a tracking spreadsheet to assist in the calculation and tracking of this information.** For individual BMPs at each site, permitees will need to track the type of practice, the IA captured, and the % runoff reduction and "disconnection" multiplier assigned to that practice. Consider incorporating these DCIA accounting elements into your program's existing BMP tracking database.

Table 4. Infiltration Trench: Percent Runoff Reduction based on EPA's Infiltration Curves

Depth of Runoff Treated (inches)	Soil Infiltration Rate (in/hr)					
	0.17	0.27	0.52	1.02	2.41	8.27
0.1	15%	18%	22%	26%	34%	54%
0.2	28%	32%	38%	45%	55%	76%
0.4	49%	55%	62%	68%	78%	93%
0.6	64%	70%	76%	81%	88%	97%
0.8	75%	79%	84%	88%	93%	99%
1.0	82%	85%	89%	92%	96%	100%
1.5	92%	93%	95%	97%	99%	100%
2.0	95%	96%	97%	98%	100%	100%

Table 5. Infiltration Basin: Percent Runoff Reduction based on EPA's Infiltration Curves

Depth of Runoff Treated (inches)	Soil Infiltration Rate (in/hr)					
	0.17	0.27	0.52	1.02	2.41	8.27
0.1	13%	16%	20%	24%	33%	55%
0.2	25%	30%	36%	42%	54%	77%
0.4	44%	51%	58%	66%	78%	93%
0.6	59%	66%	73%	79%	88%	98%
0.8	71%	76%	81%	87%	93%	99%
1.0	78%	82%	87%	91%	96%	100%
1.5	89%	91%	94%	96%	99%	100%
2.0	94%	95%	97%	98%	100%	100%

Are We Required to Follow This Protocol?

Permittees are encouraged to refine IA and DCIA baseline estimates where local data is more accurate; however the general methodology for calculating annual change in IA and DCIA should be applied. Deviations from the methodology are subject to review by EPA and must be described in the annual report.

Example Subbasin DCIA Calculations

Baseline conditions for subbasin #54203 were estimated to include 100 acres IA and 50 acres DCIA. By the second year of NPDES reporting, two construction projects were completed that resulted in an overall change in the amount of subbasin IA and DCIA as follows:

Project 1: New 5-acre residential townhome complex with 4 acres of new IA, of which, 0.9 acres drain to a bioretention facility, 3 acres drain to an infiltration basin, and 0.1 acres drain untreated to the main road. The infiltration basin is designed based on a soil infiltration rate of 0.52 in/hr and 0.8 inches of runoff captured.

Step 1. Establish new IA to add to baseline = 4.0 ac

Steps 2 -4. Determine DCIA per BMP

Eq. 3 $\text{Multiplier}_{\text{inf. basin}} = 1 - 81/100 = 0.19$

Eq. 4 $\text{DCIA}_{\text{bioretention}} = 0.9 \text{ ac} * 0.25 = 0.23 \text{ ac}$
$\text{DCIA}_{\text{inf. basin}} = 3.0 \text{ ac} * 0.19 = 0.57 \text{ ac}$

Step 5. Sum DCIA for entire site

Eq. 6 Total Project DCIA= 0.23 ac + 0.57 ac + 0.1 $\text{ac}_{\text{unmanaged}}$
= **0.9 ac DCIA to add to baseline**

Project 2: Redevelopment of an 8-acre retail outlet with 5.5 acres of existing IA. After redevelopment, there are now 6.0 acres total IA. 3.0 acres of IA continues to drain to an existing detention pond, but 1.0 acre of overflow parking was converted to pervious pavement. A new bioretention retrofit now captures 0.7 acres of IA that used to drain to the pond, as well as 0.5 acres of newly added IA. The remaining 0.8 acre of site IA remains untreated.

Step 1. Establish new IA to add to baseline = 6.0 ac - 5.5 ac
= 0.5 ac

Steps 2 -4. Determine DCIA per BMP to be added or subtracted from baseline.

Eq. 4 Added $\text{DCIA}_{\text{bioretention-new IA}} = 0.5 \text{ ac} * 0.25 = 0.13 \text{ ac}$

Eq. 5 Reduced $\text{DCIA}_{\text{porous pavement}} = 1 \text{ ac} *(1-0.25) = 0.75 \text{ ac}$
Reduced $\text{DCIA}_{\text{drypond}} = 3.0 \text{ ac} *(1-1.0) = 0 \text{ ac}$
Reduced $\text{DCIA}_{\text{bio-existing IA}} = 0.7 \text{ ac} *(1-0.25) = 0.53 \text{ ac}$

Step 5. Sum DCIA for entire site.

Eq. 6 Total Project Added DCIA = 0.13 ac + 0 $\text{ac}_{\text{new unmanaged IA}}$
= 0.13 ac DCIA to add to baseline

Eq. 6 Total Reduced DCIA = 0.75 ac + 0 ac+0.53 ac
= **1.28 ac DCIA to subtract from baseline**

End of Year Report: Totals for Subbasin #54203:

IA = 100 $\text{ac}_{\text{baseline}}$ + 4.0 $\text{ac}_{\text{project 1}}$ + 0.5 $\text{ac}_{\text{project 2}}$
= 104.5 ac *(net gain of **4.5 ac**)*

DCIA = 50 $\text{ac}_{\text{baseline}}$ +0.9 $\text{ac}_{\text{project 1}}$ + 0.13 ac $_{\text{project 2}}$ – 1.28 $\text{ac}_{\text{project 2}}$
= 49.75 ac DCIA *(net reduction of 0.**25 ac**)*

Checklist of What to Expect EPA to Provide

EPA will provide all regulated MS4 communities in New Hampshire with the following information:

- Delineation of subbasin boundaries.
- Baseline estimates of IA and DCIA for each subbasin in your regulated area in tabular format.
- DCIA calculation and tracking spreadsheet.

How Does LID Influence IA and DCIA?

Incorporating LID techniques into site design can reduce IA & DCIA, protect natural areas, and minimize alterations to existing hydrology on site. The use of BMPs that maximize runoff reduction benefits (e.g., practices with low BMP Multipliers in **Table 2** and those shown in **Figure 2**) can result in a higher "disconnection" factor than if using traditional detention ponds. Your community can help reduce total IA and DCIA by:

- Adopting LID design requirements for new development projects.
- Requiring documentation of design methods used to minimize site IA and to disconnect IA.
- Requiring site designers to calculate and submit %IA and %DCIA for each site.
- Retrofitting existing, unmanaged impervious areas.

Figure 2. BMPs such as the bioretention, porous pavers, and infiltration trenches seen here are designed to provide water quality treatment and maximize runoff reduction through improved infiltration, evapotranspiration, and plant uptake. These are effective practices for reducing DCIA.

What are the Costs of Annual DCIA Tracking?

The cost will vary depending on the size of the regulated area, amount of existing IA, sophistication of existing GIS, number of new projects requiring tracking, and the level of effort required to obtain information for each site. Refining the EPA-provided baseline estimates of IA and DCIA may require collecting new data, purchasing new software/GIS, and additional staff time. This effort may not be worth the cost if the annual **net change** in IA and DCIA is the true measure of interest. Factors that will add to overall effort may include:

- Refining EPA's baseline estimates, particularly if local IA mapping doesn't already exist.
- Over-complicating the analysis by refining given equations.
- Not easily obtaining required IA and BMP information from proposed site plans. Determine the most efficient method to obtain this information as soon as possible – changing applicant reporting requirements may be a solution.
- Verifying as-built conditions with individual site visits. Consider alternatives (e.g., occupancy certifications).
- Maintaining an updated impervious and stormwater infrastructure layer in GIS, particularly if new projects have to be hand-digitized. Possibly require applicants to submit plans electronically.
- Not integrating effort with other existing programs (i.e., plan review, building inspection, or stormwater utility).

Where Can I go for More Information?

For more information regarding the new permit requirements, go to the New Hampshire Small MS4 webpage at:
www.epa.gov/ne/npdes/stormwater/MS4_2008_NH.html

Here you will find links to relevant permit documents; community-specific mapping and statistics for baseline IA and DCIA estimates; detailed descriptions of methods used to calculate IA and DCIA estimates; and the calculation and tracking spreadsheet template.

References

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